Using Computer Games to Train Information Warfare Teams

Michael J. Cramer, Dr. Sowmya Ramachandran
Stottler Henke Associates, Inc.
San Mateo, CA
cramer@stottlerhenke.com , sowmya@stottlerhenke.com

Janelle K. Viera
AFRL/HEAS
Mesa, AZ
janelle.viera@mesa.afmc.af.mil

ABSTRACT

Information warfare and security are crucial to maintaining homeland security. An important mission of the information warfare force is to ensure that secure information and facilities are well protected. One way to ensure this is to try to gain access to this information as outsiders and see how well the practices and policies designed to protect data are being enforced. Teams of Information Warfare personnel (a.k.a. the Red Teams) are dedicated to the mission of testing the security of information and assets crucial to American interests. Most such missions necessitate deception in order to test the extent to which data is protected from strangers and parties who are not trusted. High-levels of stress are inevitable, and the Red Teams need to be highly skilled in thinking creatively under such stress. Given the criticality and the degree of danger of these missions, they have to be carefully trained. For computer-based approaches, providing realistic simulations is essential for successful training. Engaging the trainee emotionally to elicit the types of stress responses they will experience on real missions is crucial. 3D computer games have proved themselves to be highly effective in engaging players motivationally and emotionally. This effort, therefore, uses gaming technology to provide realistic simulations. These games are augmented with Artificial Intelligence techniques for enabling trainees to interact with the simulation using natural language, intelligent evaluation of the student's performance, and automated after-action review that allows the trainees to assess their own performance and provide justifications for their actions. This paper describes the details of this approach, providing examples of the simulations and after-action reviews, and discusses its benefits and limitations.

ABOUT THE AUTHORS

Michael J. Cramer is an AI Researcher and Software Engineer at Stottler Henke Associates, Inc. Mr. Cramer received his Master's degree in Computing from the Georgia Institute of Technology in December 2000. He has a diverse background in Artificial Intelligence, Systems/Architecture, and Computer Graphics/Vision, and also holds a Bachelor's degree in Mathematics. Mr. Cramer's research interests involve the development and application of behavior-based artificial intelligence techniques to a wide variety of practical domains including software tutoring systems, simulations, and robotics. He is currently working on intelligent tutoring systems for the Air Force and the Marine Corps.

Dr. Sowmya Ramachandran is a research scientist at Stottler Henke Associates, Inc. Dr. Ramachandran received her Ph.D. is Computer Science from the University of Texas at Austin. She has a strong background in a wide variety of Artificial Intelligence techniques, including Intelligent Tutoring Systems and Machine Learning. Her research interests include application of Artificial Intelligence techniques to Education Technology with a focus on addressing motivational, affective, and meta-cognitive issues. Dr. Ramachandran has headed several intelligent tutoring system development efforts for K-12 education and military training. She is currently heading an effort to develop an intelligent tutoring system for training medical teams and another for training information warfare teams.

Major Janelle Viera graduated from the United States Air Force Academy in June 1993 with a Bachelor of Science Degree in Behavioral Science. Her first assignment was to the Human Resources Directorate, Armstrong Laboratory, Brooks Air Force Base, Texas, where she worked as a Research Scientist from July 1993 to July 1995. Sponsored by the Air Force, Major Viera attended the University of Illinois, Champaign-Urbana, graduating in May 1997 with a Master of Science Degree in Applied Personnel Psychology. Upon completion of her Master's degree,

Report Documentation Page

Form Approved
OMB No. 0704-0188

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE **2004**	2. REPORT TYPE	3. DATES COVERED **00-00-2004 to 00-00-2004**

4. TITLE AND SUBTITLE **Using Computer Games to Train Information Warfare Teams**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Stottler Henke Associates Inc,951 Mariner's Island Blvd Suite 300,San Mateo,CA,94404**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**		**10**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Major Viera was assigned to the Air Force Occupational Measurement, Randolph Air Force Base, Texas as an Occupational Analyst and Plans and Programs Section Chief. In September and October 1998, Major Viera attended Squadron Officer School at Maxwell Air Force Base, Alabama. From July 2000 through June 2003 Major Viera was assigned to the 92nd Information Warfare Aggressor Squadron, Lackland Air Force Base, Texas where she served as the Aggressor Operations Assistant Flight Commander and led numerous Information Operations vulnerability assessments. Major Viera is currently the Information Operations Training Research Team Lead for the Warfighter Training Systems and Performance Branch, Warfighter Training Research Division, Air Force Research Laboratory, Mesa, Arizona.

Using Computer Games to Train Information Warfare Teams

Michael J. Cramer, Dr. Sowmya Ramachandran
Stottler Henke Associates, Inc.
San Mateo, CA
cramer@stottlerhenke.com , sowmya@stottlerhenke.com

Janelle K. Viera
AFRL/HEAS
Mesa, AZ
janelle.viera@mesa.afmc.af.mil

INTRODUCTION

A critical aspect of national security known as Information Warfare (IW) involves actions taken to gain and exploit information about hostile threats while also protecting sensitive information from getting into the hands of the enemy. The advent of the Internet has brought an explosion in information traffic. Sharp skills are required to be able to sift through volumes of information efficiently, yet remain vigilant for crucial data or evidence. With warfare shifting from traditional battles to terrorist tactics, and the enemy changing from states to amorphously widespread, yet very potent terrorist organizations, information is becoming more of a crucial asset. Information gathering and analysis is critical; and at least of equal importance is the task of defending the security of one's own sensitive information. Creating and maintaining a highly trained information warfare force can mean the difference between victory and defeat.

An important mission of the information warfare force is to ensure that secure information and facilities are well protected. One way to ensure this is to try to gain access to this information as outsiders and see how well the practices and policies designed to protect information are being enforced. Teams of Information Warfare operators (henceforth referred to as the Red Team) are dedicated to the mission of testing the security of information and assets crucial to American interests. Most of these missions necessitate deception in order to test the extent to which information is protected from strangers and parties who are not trusted; high-levels of stress are inevitable in such scenarios, and the operators need to be highly skilled in thinking creatively in the face of such stress. Given the criticality and the degree of danger of these missions, the teams have to be carefully selected and trained. It is important to ensure that new operators have the skills and personality necessary for these missions.

THE TRAINING PROBLEM

The Red Team currently undergoes an intense schoolhouse training program designed to instruct new recruits. This immersive course then teams the trainees with experts and places them in real-life missions to test their performance under these conditions. However, relying on real missions for practice opportunities presents limited chances for new recruits to practice and test their skills. Also, different students have different training requirements. Depending on background, years of experience, and learning speed, some trainees may need less hours of training than others to reach the same level of proficiency of a given skill. Moreover, different students need training in different areas, even within the same tasks. Ideally, the instructor would provide a tailored curriculum specific to a particular trainee's needs. However, this kind of tailored individualization of instruction is infeasible due to high student to instructor ratio. Traditional instructor-led classroom training is inefficient because it cannot accommodate these differences. Further, instructors cannot always monitor an individual student's progress or lack thereof. In a class of tens or hundreds of students, it is impossible to present a course that is customized to everyone's individual differences. As a consequence, some trainees have to stay the required number of hours even when they have mastered the skills, while others don't acquire enough proficiency in the given amount of time.

The course instructors would benefit immensely from a method or procedure that could help them assess the competency of individuals attending the courses – prior to the actual training – so that they can be appropriately tuned. The students would also stand to gain much more from the coursework if they are able to obtain reasonable expectations of the skills that will be required of them. Furthermore, there is an ongoing need to provide additional practice opportunities beyond training, but live exercises are

expensive to conduct and have costly time and travel demands.

Simulation-based training can provide a cost-effective alternative to instructor-led training where trainees can practice their skills under various conditions in realistic but simulated scenarios. Simulations have been shown to be very effective for promoting strategic thinking and procedural skills (Schank, 1995). They alleviate the need for costly on-site support and the demand for live training opportunities. Trainees are free to participate as their schedule permits and need not all be present at one location. Instructors need not be present at all. While they are not fully intended to replace live training, a simulation-based environment can be an effective augmentation for information warfare training and also provide the capability for distributed simulation.

The military is increasingly moving towards distance learning initiatives, where trainees can participate from remote locations yet still work together as a team, thus reducing travel time and money. The Internet provides an opportunity to reach more personnel in more geographically diverse locations by providing long-distance learning and delivery of multimedia. Unfortunately, current Internet training systems have been developed in a variety of styles with little reference to sound pedagogical principles. They often have an impressive array of graphics, video, and animation, but functionally are little more than simple page-turners. The only customization to individual students' needs is accomplished by having the student self-pace the presentation of the information, usually via navigation through a hyper-linked, multimedia textbook. When students require assistance, they have to communicate with an expert via telephone or other media. This creates a bottleneck and causes delays as students vie for the instructor's time and await response.

The solution to this training problem is a simulation-based distributed training environment that is highly responsive to a trainee's learning needs. It should enable assessment of a student's strengths and weaknesses and provide rich and extensive practice opportunities beyond the course itself, both as prerequisite training and post-deployment refresher training. An advanced artificially *intelligent* training system can address these needs, assess student knowledge in real time, diagnose deficiencies, and provide a tailored remedial course of instruction on the fly. Such intelligence is crucial to distance-learning programs because it would off-load many of the tasks traditionally performed by instructors.

THE BENEFITS OF USING GAME TECHNOLOGY

The most important factors in this domain are the richness and realism of the human interaction, and the ability to think creatively under duress. The simulation absolutely *must* give its participants both a sense of control and consequence, while suspending reality to the largest extent possible. Modern 3D games – such as those commonly known as "first-person shooters" – have been long pushing the boundaries of realism by combining cutting-edge graphics and real-world physical modeling with complex character behaviors and intriguing story lines complete with conflict and resolution. Together, this results in a powerfully immersive environment that engages and captivates the attention of the player and elicits realistic emotional responses from them, while at the same time stimulating a player's problem solving abilities.

Games seem to motivate players intrinsically by stimulating curiosity (Thomas and Macredia, 1994). A sense of accomplishment is gained by a thorough comprehension and mastery of the causes and effects in the gaming environment; hence there is a strong desire to understand it. The theory of constructivism states that, by evaluating and reflecting upon our own experiences in that environment, we construct an understanding of the world based on the rules and mental models we already have in place. If a game can serve as an adequate simulation of the real world and the actions of the constituents within it model their real world counterparts, then the game can serve as a very effective learning tool. This "learn by doing" approach is known to be an extremely effective educational tool (Schank, 1995).

A great example of this is the flight simulator (Prensky, 2002). Originally conceived as an entertainment device for fairs, the flight simulator is one of the single greatest advancements in training technology. Pilots can spend hours honing their flying skills under a wide variety of scenarios, varying weather, location, flying conditions, visibility and even dynamic events such as mechanical failures. There is no danger to equipment or lives, and trainees are free to try out any number of possible courses of action.

Modern gaming technology contains extensive support for both single and multiplayer environments. A single player environment consists of a single human player interacting within the simulation via a set of controls including – but not

limited to – a computer keyboard and mouse. The simulation consists of a pre-constructed world that behaves according to a model based on real rules of physics and contains one or more artificially intelligent non-player characters (henceforth known as NPC's) acting within that world. Each character (both players and NPC's) have a physical embodiment in the game world (such as a pawn or avatar) and can only move and interact in accordance with the physical rules of that embodiment. Multiplayer environments have more than one human player and any number of NPC's (or none at all) participating over some networking medium. These environments also support any number of omniscient observers having no physical effect upon the world but able to observe the various internal and external states of objects within that world.

Single player environments can be used to provide initial training at an individual level. The NPC's in these scenarios play the role of tester by assuming the roles of the "opposing" characters in the scenarios – roles that would normally subsume the time of the instructors. This is ideal for self-paced training. The trainee is then free to attempt any number of scenario permutations as his or her time will allow. Moreover, intelligent tutors partake in the scenario, taking note of the tasks that the student performs poorly as well as documenting the student's strengths. They report this information to both the student and the instructors in the form of after action review, giving the instructors advance knowledge of the student and giving the student an idea of what the instructor will expect.

Multiplayer environments can support more advanced training where teams of trainees, experts, and instructors can participate in a simulation simultaneously from remote locations. The tutor will take a back seat in this approach, making only observations, while coaching and after-action review is performed ad hoc by the instructors. This saves in travel time and expense as well as provides a convenient medium for continued training well after the coursework is complete.

DEVELOPING A GAME-LIKE SIMULATION

The game is the cornerstone of computer-based training; it is important to assure that it will be immersive, realistic, and educational. Therefore a compelling prototype was the primary thrust of our initial effort, Phase I of USAF SBIR F33615-03-M-6349. It was designed to assess the feasibility of developing a system that satisfies the needs thus far discussed. We implemented this prototype taking into account the necessary design considerations of a fully functional system – a simulation-based intelligent tutoring system (ITS) to complement the existing course – targeted for completion at the end of Phase II of this effort.

For this prototype, we focused on the single player aspect of the game, where trainees interact with simulated characters. We drafted a training scenario and storyline using actual case studies and guidelines gathered from our subject matter experts, the graduates and instructors of this in-house course. Then we devised game parameters and rules to establish motivation and direction for the game play. We used a commercial game engine, Unreal Tournament 2003™, and its associated construction tools to provide the physical modeling and graphical rendering of our simulated environment. Finally, we played the game through all the encounters to test the validity and authenticity of each encounter.

The Scenario

The scenario begins outside a military facility where the trainee and his assistant (an NPC) will attempt to infiltrate a high security network using a wide variety of covert strategies and persuasion techniques. The two are faced with a series of seven encounters, where they will be confronted by hostile characters (NPCs) that will likely be suspicious of their activities.

Figure 1 shows a screen shot from the beginning of the game, just as the player has entered the facility. If the trainee successfully persuades the character into performing a desired action (such as letting them pass through or escorting them to the servers) they move on to the next encounter. Once the trainee successfully proceeds through all encounters in the scenario, then he has succeeded in the lesson plan. If a trainee is denied access, or arouses a high level of suspicion, he is deemed to have failed in the lesson.

In each encounter, there are opportunities for the trainee to increase or decrease suspicion and anxiety levels. The suspicion level refers to the overall sense of mistrust that the facility has for the player and is influenced by the interaction of the player with each of the characters throughout the scenario. It is important to maintain minimal suspicion levels as it will determine the overall success or failure of the mission. The anxiety level refers to the level of tension and worry that the trainee's assistant is experiencing. The player needs to maintain minimal

anxiety in his assistant, as it will affect her ability to function smoothly and efficiently.

Figure 1: View at start of game.

Simulated characters form the primary obstacle to the completion of the scenario. They will confront the trainee about the details of his presence in a given area, or about the actions in which he is attempting to engage. The trainee *must* successfully persuade them that his presence and activities are normal and legitimate. Failure to do so can cause immediate mission failure or make subsequent encounters much more difficult and stressful. Given the limited scope of the prototype, the interactions between the trainer and the other characters are scripted with branching to enable multiple paths through the script depending on player responses. At each decision point, the character with whom the player is interacting will ask a question or perform an action requiring a response. The player is presented with a numbered set of response choices any of which he can choose, or he can opt not to select anything. If a player does not select an option within a preconfigured amount of time, a "no response" is assumed and is considered a perfectly valid decision (though not necessarily a good or bad one). The player's choice at each point determines the subsequent behavior of the NPC and can affect the suspicion and anxiety level of the game. Figure 2 shows a screen shot of one of these decision points with a set of response options displayed.

In addition to the question interface, the game also features a heads-up display (HUD) text overlay that contains dynamically updated game information: current suspicion level, anxiety level, time elapsed since the start of the game, and any useful inventory items collected from the surroundings. These are visible in the upper left, lower right, upper right, and lower left corners of Figure 2, respectively. This is a reference guide to help the students make appropriate choices and get immediate feedback regarding the effects of his decision. The display is updated in real time. Whenever a player's decision raises or lowers suspicion (or anxiety) the display is updated immediately so that a player gets the appropriate positive or negative reinforcement. In addition, a player can monitor time as well, since he or she has a limited time to complete the objective.

Figure 2: Question interaction from first encounter.

A player is evaluated on his ability to keep suspicion levels to a minimum, and his ability to manage the anxiety level of his assistant. When the suspicion level reaches a maximum limit, the game ends and the mission fails. Also, high suspicion levels may lead to more skeptical behaviors from the scenario characters, making it even harder for a player to complete his mission. High anxiety levels lead to more erratic behavior from the player's assistant, which in turn can induce suspicion if not handled appropriately. Further, high anxiety impedes the assistant's ability to work quickly, opening more opportunities for dubious characters to interject further probing inquiries.

The player controls movement by keyboard and mouse (or alternatively, a joystick). The configuration of these controls assumes the standard Unreal Tournament 2003™ default. As with any game, the controls can be remapped according to the trainee's preferences. Players can look around by moving the mouse around (commonly called "mouseview" in gaming terminology) and move backwards, forwards and sideways (strafing) by pressing a key or mouse button, depending on how that trainee has his or her keys mapped. Pawns do not have much physical capabilities in the prototype

(such as jumping, crouching, and running) due to the limited scope of the project and the fact that the scenario does not call for it. Table 1 provides a brief description of the encounters.

Table 1: Encounter descriptions.

	Description	Possible Effects
1	The trainee is confronted by the guard at the front desk who questions the validity of the trainee's ID.	Heightened suspicion, increased anxiety if the trainee cannot downplay the obvious poor quality of the ID.
2	The trainee is questioned casually by an affable escort who is lamenting the current state of security.	Heightened suspicion if the trainee appears too secretive and standoffish about their work.
3	The trainee and assistant are questioned by a technical person who happens upon them in a corridor.	Increased suspicion and anxiety if the trainee does not allow the assistant to handle the more technical questions to which she is better suited to answer.
4	The trainee must allay his assistant's anxiety about having her bag scanned through an X-ray machine.	Increased suspicion and anxiety if the trainee does not remain calm and attract attention.
5	The assistant is probed by the second escort if much attention was attracted in the second encounter.	This encounter only occurs if the previous one resulted poorly. The trainee must again defuse the situation or more suspicion will result.
6	The trainee must provide distractions to the escort while his assistant performs the security breach.	Increased suspicion, failure of mission if poor distraction techniques are chosen.

System Architecture

The bulk of the work effort for this prototype was dedicated to developing a realistic game environment and engaging storyline. However, it is important when developing a prototype to account for the requirements of the target system and the prototype architecture should reflect that to a reasonably large extent. To this end, we've implemented a minimal architecture satisfying the demands of the scenario we have put forth, but allowing for additional extensibility and refinement without impacting anything in place thus far. While the architecture of the Phase II product is beyond the scope of this paper, some aspects of intelligent tutoring specific to this domain are discussed in the next section. The simplified architecture for the prototype is depicted in Figure 3.

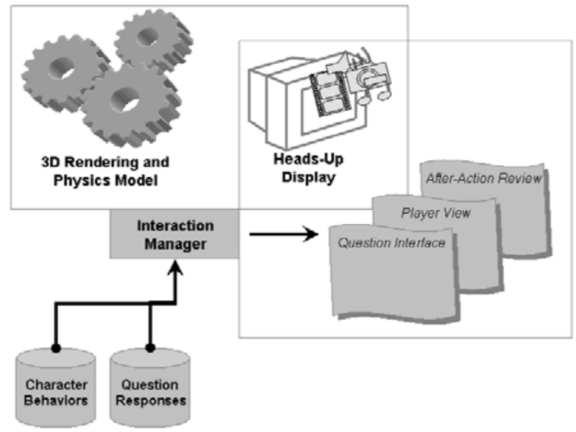

Figure 3: Overview of the prototype architecture.

As mentioned previously, we used the Unreal Tournament 2003™ game engine for building the game environment. It comes equipped with CAD-like modeling software which was used to build the world and a proprietary scripting language which we used to construct the character behavior, game rules, and evaluation. The game engine renders all graphics and animation, plays sounds and controls game play. At the heart of the system is the interaction manager which controls the game flow, sequencing each encounter and signaling each of the simulated characters and evaluates the current state of the game. The interaction manager oversees decisions by prompting the player when possible decision points are reached. The heads-up display provides a window into the game play by presenting a first-person view of the environment, response options and review at the end of the game.

AUGMENTING THE GAME WITH AUTOMATED, REFLECTIVE AFTER-ACTION REVIEW

The training course augmentation needs to be a realistic simulation-based training system that provides assessment information to instructors. Due to the high unpredictability and randomness of this domain, it is difficult – if not impossible – to devise a single evaluator that instructs the student in a manner that is in accordance with all domain expertise. In other words, a lot of situations present cases where a decision is not clearly right or wrong. Each choice has a number of outcomes possessing variable desirability, based on factors ranging from the strengths and weakness of the student to

unpredictable dynamic factors in the scenario. In these cases there is no absolute right or wrong, only varying consequences of particular actions, and the student should have some idea of each and every one of these outcomes. Therefore, the tutoring strategy in which they are most interested is *reflective* after-action review. We accomplish this by taking a multiple agents-based approach to review. Rather than conducting evaluation from a signal, evaluator, a number of agents are selected to conduct the review (which will be explained in the next paragraph). After review is complete, a model of the trainee's performance is constructed using the tasks and skills that the trainee performed exceptionally well, as well as those that the trainee performed poorly.

The Panel of Judges Approach

To accommodate this wide range of feedback permutations, we've devised an innovative evaluation system that mimics the effect of multiple instructors. In addition to the implementation of a large number of evaluation "behaviors", each of these behaviors will also have personality attributes that affect the behavior accordingly. For example, while two evaluators are analyzing a student's actions in one particular encounter, one evaluation entity could be very strict and demanding, "playing it by the book" while the other could be more lenient and focused on positive reinforcement and creative thought. Then, during the after-action review, the student is presented with a "panel of judges" that each weigh in on the student's performance. These agents can behave outside their character at random times to avoid predictability, if necessary. In addition to a composite score representing the student's overall performance, each evaluator reports its own viewpoint on the student's decisions. This is not restrained to general dispositions, either. A particular evaluator may have a bias toward a particular problem-solving or stress management approach and may thus appear more favorable when a student takes that approach and more critical when a student does not.

To enrich the variety of scenario evaluations, the tutor will assign personality types to the judges randomly at the start of a scenario. This implies that repeated runs of the same scenario would be different as agent personalities will be instantiated differently. The same can be said for the NPC's working within the scenario. For example, one run might include a gullible escort who may not question the trainee much, while another run might include a skeptical escort who will grill the trainee thoroughly. This makes it possible to get several different types of evaluations from a single scenario specification.

Student Modeling

This element maintains a dynamic model of the student. This information is crucial for determining the next instructional step, for scenario selection, and character selection. In the past we have used various metrics such as percentages of correct usage of a principle and Bayesian probability inference to measure skill mastery. The technique depends on the organization of the principles, and the degree of interdependence between the principles. While it is important to "score" the student for grading and accounting purposes, for this domain, it is more important to minimize the importance on placing a score on the student's performance, and place more emphasis on providing detailed feedback to the instructors so that they can make the appropriate decisions as to where the student needs more work.

At the end of the Phase I development effort, we demonstrated a preliminary version of the prototype to representatives from the user group and received various suggestions which have been incorporated into the Phase II design. While most of the suggestions were related with the fidelity of the graphics, which can be addressed quite easily, there was one suggestion that stood out for its technical implications. The users require that the interactions of the user with the other non-playing characters not be restricted to multiple-choice responses. We have folded in this requirement into the Phase II prototype by proposing to use Latent Semantic Analysis and other template-based techniques to allow trainees to communicate with the world through free-form inputs in either natural English or a close subset.

ANALYSIS OF THE BENEFITS AND COSTS OF THE APPROACH

The project is in the second phase under an Air Force SBIR contract and development is estimated to occur during FY2005 and FY2006. The development team is currently projected to consist of 2-4 programmers, 2-3 artists, a storyboard consultant and a project manager. Provisions have also been made for the development of a scenario authoring toolkit, whereby subject matter experts can tweak scenarios and behaviors to other requirements. At the completion of this effort, the system can be maintained by one technical consultant per distribution site and a small team of instructors (at any location) to oversee training.

One potential intangible cost is the lack of human involvement as the ITS assumes a more prominent role in the student curriculum. As more of this instruction becomes automated, the human instructors become estranged and oblivious of individual students' needs. However, it is important to note that this system is not intended to be a *replacement* for human tutelage, but rather an augmentation. Since a few instructors are relied upon to teach many students, the instructors must utilize the time that they *do* get to spend wisely, and thus address the students' most glaring needs. In this way, the ITS is used as a *pre-assessment* and *post-follow-up* tool that can automate some of the instructor's more mundane and rudimentary tasks and formulate a general overview of the student's strengths and weaknesses.

Training via simulated environments and ITS can be repeated ad nauseum or until the student has a good idea of the concepts and principles that will be expected of her. This way, when actual one-on-one training begins with human instructors, students have a better idea of what to expect and can anticipate being better prepared for their encounters. This will facilitate learning and make optimal use of both the instructor's and student's time and require less training in the long run. Furthermore, students and instructors can participate at any location, relieving them of costly and time-consuming travel requirements. Instructors will also have the capability to oversee a large number of trainees simultaneously by playing the role of omniscient observer. They need not participate in the scenario, but can quietly watch behind the scenes as players interact with one another and with simulated characters. This further allows them to build their own conceptions of student strengths and weaknesses without costly one-on-one personal interaction. When necessary, they can intervene in any scenario and give necessary feedback and advice.

We will conduct studies to evaluate the quantitative and qualitative effectiveness of the tutor provisional on the availability of students. The precise evaluation methodology will depend on the number of trainees available for the study, and the amount of content authored by the subject matter experts. Quantitative studies require larger number of participants and long-term use requiring extensive content to provide any conclusive results about training effectiveness. If the conditions are not supportive of such a large-scale study, we will conduct qualitative studies that require fewer resources in terms of participants and content.

CONCLUSION

The ITS we have developed combines gaming technology with ITS technology, resulting in a training tool that is at once engaging, adaptive, and flexible. Games have always had the capacity to engage players motivationally and emotionally. They recently have begun to attract the attention of developers of computer-based training programs. However, games by themselves have limited potential as training programs unless they can provide a degree of automated coaching, tutoring, and feedback. Without these elements, games, like simulations, will suffer from the problem that trainees will play games without necessarily learning much from them. Learning requires structure and feedback to complement inspiration. ITS technology can enhance the training potential of games by providing these elements. The proposed effort is a step towards marrying the two technologies.

Our system has an innovative reflective, after-action review component for leading trainees through an assessment of their performance in a domain where there are no clear right or wrong answers. The objective of the after action review is to let the trainee reflect on various perspectives and draw their own conclusions as well as provide the instructors a complete overview of student performance without generalizing to a strict set of principles and guidelines. We believe this will provide a very cost-effective solution to pre-training evaluation and remedial learning.

RELATED WORK

Our prototype is an innovative combination of gaming and intelligent tutoring technology. However, the idea for using games as a training tool is not new. The U.S. Army has been using games as a means of training and recruitment for some time now. America's Army, Full Spectrum Command, and AWE are three examples of how gaming has come to the forefront of training methodologies.

America's Army

America's Army is an Army-based 3D computer game designed to depict the authentic U.S. Army experience. This includes the units and equipment used in real Army maneuvers, and multiplayer missions that involve direct action, surveillance, reconnaissance and combat search and rescue. Players conform to the laws of land warfare, Army values (honor, duty and integrity) and realistic rules

of engagement as they work together to accomplish their mission, receive evaluation and progress up the ranks on the way to becoming a Green Beret. This game was conceptualized by the Army as a recruiting tool, but has developed into a very popular, massively multiplayer game. As such, it has very little in the way of actual training and instructor feedback and is used primarily for entertainment purposes.

Full Spectrum Command

Full Spectrum Command is a PC-based training aid that models the command and control of a U.S. Army Light Infantry Company in an urban environment. As the captain of the company, the player receives orders for a given scenario, organizes her platoons, and coordinates the actions of her soldiers during the engagement. The scenarios were designed to develop critical cognitive skills such as tactical decision-making, resource management and adaptive thinking. These scenarios are focused on asymmetric threats within peacekeeping and peace-enforcement operations. Each scenario was developed with the aid of the US Army Infantry Center in Fort Benning, Georgia and subject matter experts from the Singapore Armed Forces to ensure both military and pedagogic fidelity. This game focuses more on training than America's Army and emphasizes learning by doing, though it still lacks a strong instructor feedback model and course framework.

Asymmetric Warfare Environment (AWE)

Asymmetric Warfare Environment is a massively multiplayer simulation that will be used by military personnel to train troops in urban situations before they are airlifted to a battle zone. The goal is to train soldiers mentally for what can be a very trying experience. The game does not concern itself with AI since there are so many players participating; it is designed to bring players together from all over the world. Its rich content is delivered through a large, private broadband network owned by the U.S. Army. This medium allows them to bring ideas and share experiences in a realistic environment. This is much more closely in line with our vision; however, we see the addition of AI as a valuable tool for offloading some of the instructional and feedback duties.

ACKNOWLEDGEMENTS

We would first like to acknowledge the invaluable contributions of the graduates and instructors of this course for their thorough descriptions of covert operations techniques and depiction of real-life scenarios. This knowledge is critical for realistic game play; without their ongoing support, we could not have acquired the level of realism necessary for a simulated training scenario.

We would also like to thank our consultants at Bellicode: Kimberly Ungar, for conception, character design and packaging, and Andrew Rohs, who designed the entire layout of the facility and all artwork and graphics. We express our gratitude to Coray Seifert of Blade Edge Software for contributing the storyline and game play as well as Raison Varner of Straius Music for all the voices and sounds.

REFERENCES

Prensky, Marc. (2002). The motivation of gameplay *On the Horizon, Vol. 10, No. 1.*

Schank, Roger C. (1995). What we learn when we learn by doing. *Institute for Learning Sciences, Technical Report No. 60*, Evanston, IL: Northwestern University.

Thomas, P. and Macredie, R. (1994). Games and the design of human-computer interfaces. *Educational Technology, 31,* 134-142.